OVERVIEW ON APPLYING RISK MANAGEMENT DALLAS FLOODWAY EXTENSION PROJECT

by
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GENERAL

Background. Since the 1960's, the Corps has undertaken a number of studies directed at developing a feasible, acceptable solution to the flooding problems within the city of Dallas, TX. In 1965, Congress authorized the Dallas Floodway Extension (DFE) project for construction as part of a basin-wide plan of improvement for the Trinity River and Tributaries. The recommended plan of improvement consisted of a combination of 18 .6 miles of flood control channels and 22 miles of floodway levees extending downstream of the existing Dallas Floodway Levees. The plan was designed to provide for Standard Project Flood (SPF) level of protection (880-year event or 0.125 percent probability of exceedance) within the protected areas and also designated 5000 acres between the levees for the development of a greenbelt-recreation area. The study area, depicted in figure 1, extends downstream from the Atchison, Topeka and Santa Fe railroad bridge to Interstate Highway 20 bridge, a distance of about 5 miles. The total cost of the recommended plan was estimated at $199.2 million (1997 prices).

The project was placed in an inactive status in 1985 because the local sponsor, the city of Dallas, was unable to fund its project responsibilities due to failed bond election. Following severe floods in 1989 and 1990, which resulted in loss of lives and widespread flood devastation, the local sponsor requested that the DFE project be placed in the active status. A reevaluation was initiated Fort Worth District in January 1991.

Between 1991-1994, the local sponsor constructed levees in two areas that historically had experienced repeated heavy flood losses. One levee was placed on the left bank of the Trinity River to protect a residential area referred to as “Rochester Park Area” and the other levee was placed on the right bank around the Dallas Central Waste Water Treatment Plant (CWWTP). The City designed both levees to offer SPF level of protection (0.125 percent probability of exceedance). Subsequent Corps hydrologic and hydraulic studies revealed; however, that the Rochester Park Levee and the CWWTP Levee offered only approximately 110-year (0.90 percent probability) and 140-year (0.71 percent probability) levels of protection, respectively. The earlier City design was found to have inadequately accounted for extensive upstream urban development changes which in turn had dramatically altered the river’s runoff and downstream river stages.

Language in the Water Resources Development Act (WRDA) 96' contained provisions for credit reimbursement for the non-Federal construction of these levees if they were found

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compatible with the authorized DFE Project, including any subsequent modifications. In response to this legislation recent Corps studies strived to incorporate these locally constructed levees into the various alternatives considered, where engineering practicable. The local sponsor's cost for construction of these two levees totaled $27.0 million.

REFORMULATION ACTIVITIES

National Economic Development (NED) Plan Formulation. Corps reformulation activities conducted between 1991-1993 led to identification of the NED plan which recommended construction of an upper and lower 1200-foot bottom width swale (wide shallow ditch or overflow channel), extending over a distance of about 4.8 miles and included provisions for associated linear recreation features. Construction of the NED swale plan would eliminate 725 acres of mature bottom land hardwood forest land, requiring the purchase of 3,200 acres of lands at a cost of $13.5 million to mitigate the bottomland hardwood losses. Approximately 74 percent of the benefits for the NED plan would occur upstream in the area protected by the existing Dallas Floodway and 24 percent in the area currently unprotected. The estimated first cost of this plan totaled $50.0 million. Widespread opposition surfaced to the NED plan, primarily because of the extensive adverse environmental impacts associated with the project's construction. This led to the formulation of the more environmentally sensitive plans described below.

Chain of Wetlands (COW) Plan. First, two smaller swales were designed and relocated to reduce the destruction of bottom land hardwood forest lands as much as practical. Wetland features were then incorporated into the project features. This design, referred to as the COW plan, like the NED plan, provided for upper and lower swales. The upper swale would have a 400-foot bottom width and extend over a distance of about 1.5 miles and the lower swale would have a 600-foot bottom width and extend over a distance of about 2.2 miles. Approximately 287 acres of evacuated wetlands and tree plantings were added as environmental restoration features within the foot print of the project lands to gain environmental support. This plan reduced the impacts to bottom land hardwoods to 287 acres, requiring 825 acres for mitigation. A total of 265 habitat units would be generated from the environmental restoration features. Approximately 73 percent of the benefits would occur upstream in the existing Dallas Floodway and 27 percent in the area currently unprotected. The estimated first cost of this plan totaled $ 48.9 million.

Locally Preferred Plan (LPP). At the local sponsor's request, two earthen levees were added to the COW plan to gain higher levels of flood protection for residents living in currently unprotected areas. The east levee, referred to as the "Lamar Street Levee", would extend downstream from the existing Dallas Floodway levee to the city constructed Rochester Park Levee. The west levee, referred to as the "Cadillac Heights Levee", was added to the city constructed CWWTP Levee. Both levees, which offer SPF protection (0.125 percent probability of exceedance), would have average height of 21 feet and span a distance of about 3 miles. The LPP would adversely impact 600 acres of bottomland hardwood lands, requiring 1400 acres of mitigation lands. Approximately 62 percent of the benefits for the LPP would occur in the area protected by the existing Dallas Floodway and 38 percent in the area currently unprotected.

First Costs, annual costs, and annual benefits for each of the plans discussed above are summarized in Table 1.

TABLE 1
SUMMARY OF THE PROJECT ECONOMICS- FLOOD CONTROL ONLY

Item	NED Plan	COW Plan	LPP Plan
	(In millions of dollars)		
First Cost	$50.0	$48.9	$76.8
Annual Costs	5.5	5.1	8.7
Annual Benefits	13.6	10.5	11.7
Net Benefits	8.1	5.4	3.0
BCR	2.5	2.1	1.3

Project Status. A draft General Reevaluation Report, including an Environmental Impact Statement, is scheduled for release for concurrent policy and public review in October 1997. The report recommends designation of the Locally Preferred Plan (LPP) as the Federally supportable plan for cost sharing purposes. An exception is being sought from Assistant Secretary of Army (Civil Works) to allow full Federal cost sharing of the LPP. Congressional authorization is being sought in the upcoming WRDA 98' for the environmental features in light these features were not part of the plan originally approved by Congress in 1965.

RISK MANAGEMENT ANALYSIS

Analysis Performed. Through 1996, traditional procedures were used, relying on single points rather than probabilities to define frequencies, to calculate hydrologic values for with and without project conditions. The resultant hydrologic and hydraulic data were incorporated into the engineering and economic evaluations to calculate damage and benefit estimates and the concept of freeboard was used to account for hydraulic uncertainty in levee designs. Preliminary alternatives were first formulated following the procedures described above.

Selected alternatives were subsequently reanalyzed, in accordance with guidance contained in ER 1105-2-100 and ER 1102-2-101, first using a HEC “risk based” spreadsheet add-on program that entitled” @Risk and later using the risk-based software program entitled HEC-FDA. Both the @Risk and the HEC-FDA programs incorporated Monte Carlo simulation techniques into the analysis to evaluate the hydrologic, hydraulic and economic uncertainties

associated with the various alternatives investigated. H&H uncertainty parameters given consideration included water surfaces, frequency/discharges, stage/discharges, etc. Economic uncertainty parameters considered included stage/damage functions, threshold flood elevations, flood damages and benefits. Nearly 90 years of rainfall and flood records were available for use. These lengthy records aided in improving of the accuracy of the analysis, as reflected in the relatively narrow confidence bands of resulting regression equations.

The risk-based analysis undertaken in formulating the final plans focused on optimizing levee design performance, giving consideration to the value and types of development to be protected. Recommended levee crest design grades were selected through analysis of water surface profiles verses different levee heights. Similarly, risk-based procedures were applied to compute the estimates of annual damages, annual benefits, residual damages, and the probability of exceedance of various floods for the final plans investigated. The resultant levee failure probabilities under with and without project conditions are listed in Table 2. The local sponsor was faced with several challenges in selecting the LPP for the DFE Project. Most importantly was offering high levels of protection in downstream areas that had experienced reoccurring heavy flooding over the years. Secondly, the City desired to restore the existing upstream levee system to their original levels of protection. The upstream levees, which were constructed in the 1950's, were designed to have a probability of exceedance of 0.125 percent. Extensive upstream development throughout the watershed had reduced the probability of exceedance on these levees to 0.333 percent. Obvious tradeoffs were necessary in selecting the LPP because of social equity issues and because the types and design of flood protection measures (channels and levees) selected downstream inversely affected protection levels achieved in upstream areas. As reflected in the table, the local sponsor selected a solution that offered balanced, high levels of protection in all the affected areas.

TABLE 2
LEVEE FAILURE PROBABILITIES

Location	Existing Conditions	With Project Federal (NED) Plan	LPP Plan
	Probability of Exceedance (in percent)		
Existing DFE Levee			
East Levee	0.333	0.111	0.125
West Levee	0.142	0.111	0.111
Existing Unprotected Areas			
East Side of the River	N.A.	0.125	0.125
West Side of the River	N.A.	1.0	0.125

Note 1. The probability of exceedance of the Central Waste Water Treatment Plant is 0.2.

Defining Risk. At the request of the local sponsor's technical staff, the Standard Project Flood (SPF) event and other single frequency events (expressed in years) were used to communicate risk to the local decision makers and to the public throughout the study. The SPF event reflected a "simple "standard" that local decision makers and the public found more easily understandable to make comparisons on the project's performance. The SPF event was defined as the flood that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered to reasonably characteristic of the geographic region involved, excluding rare combinations. Subsequent risk-based analysis revealed that the SPF (defined to be approximately an 800 year event) to have a 0.3 to 0.08 percent probability of being equaled or exceeded in any year, and between 40 and 60 percent of the a Probable Maximum Flood.

PERCEPTIONS OF RISK AND UNCERTAINTY ANALYSIS

Corps Analysts Views. In early 1996, HEC staff conducted a one week Risk and Uncertainty Training Course in Fort Worth District. Selected interdisciplinary team members received specialized instruction on the use of HEC-FDA software program and applying risk-based methods. As one would expect some start up time was required for Corps team members to learn the necessary skills to perform risk-based analysis. Team members appreciation of the additional valuable analytical data gained from using a risk-based approach to make formulation decisions increased as their knowledge expanded.

Local Sponsor's & Public's View. As noted above, the local sponsor technical staff requested that probability results not be incorporated into the information provided to the public and others. Timing and lack of understanding of the merits of risk-based analysis contributed to this decision. The study had been underway over five years when risk-based analysis tools were introduced into the study process. Prior to their availability, traditional measures had been used exclusively to describe the project's performance. From the questions that arose during the study, it was apparent that many non-technical individuals had varying difficulties understanding the performance data even when presented in a more simpler form. Given these circumstances, the local sponsor believed changing to more complex, risk-based data would only lead to increased confusion. Other factors also influenced the LPP selection which could not be analyzed through computer simulation. One being, the sponsor's desire to address a sensitive local social equity issue, in that the project was located in an lower, social-economic area which the City had neglected over the years.

LESSONS LEARNED

Observations and Recommendations. The District learned a number of important lessons from performing risked-based analysis on the DFE Project. Observations on our experiences and recommendations to aid others in performing future risk-based assessments are offered below:

- Formal training is strongly encouraged for technical staff to be assigned to

perform risked-based analysis. Based on the District staff's experiences, undertaking advanced training measurably helped those involved to more efficiently perform the required analysis; to more capably understand and interpret the analysis results and make determinations on the relative importance of the findings; and to more easily convey the results to others.

- Corps staff found the HEC-FDA software program to be user-friendly. This included its ease to input data, to perform the required analysis, and to read and interpret the analysis results. Team members did request several minor modifications be made to the program software. Due to the infrequent reoccurrence interval for overtopping of the levees, the maximum number of interactions the program would accept had to be increased to 500,000 in order to obtain reasonable results. Minor adjustments were also made to allow more significant digits to input for the hydrologic data.

- Team members found that it was very easy to make simple errors which can significantly impact the analysis results given the mass of data being handled. An independent, thorough review of the program input and results is suggested to reduce the potential for these types of problems and improve the accuracy of the analysis results.

- District team members found working independently led to frequent miscommunication and led to an unacceptable number of errors slipping into the database. It believed that others would benefit if they did likewise.

- Education of local sponsors, the public, and others on the merits of incorporating statistical, risk-based approach into the formulation\decision process is a difficult issue all Corps face. Based on the District's experiences, one needs to start early in the process and continue to build on everyone's understanding as the study proceeds. In this regard, simplified charts, graphs and displays are needed. Risk based assessment procedures also need to be incorporated from the beginning and continued throughout the formulation process, if maximum benefit is to be gained by all.

- To conclude, the District gained invaluable knowledge from its first attempt in applying risk assessment procedures. Corps and local sponsor specialists acceptance of this new process, while taking longer than desired, grew along with their appreciation and understanding of the merits of using a risk-based approach. Some minor costs were required to train technical staff; however, early concerns and misconceptions that a risk-based approach would lead to considerably higher study costs proved false. One major benefit noted was that resulting statistical data generated from the risk analysis assured the decision process focused on critical formulation and design issues which often went largely ignored in the past. Continued emphasis on education of all the stakeholders on the merits of using a risk-based approach needs to be a top priority. Key to greater understanding, it is believed, is showing its value in making decisions, in the selection of project features, in making tradeoffs in costs of different designs, etc.